24/7 ZEN

REVERSIBLE SOEC/SOEFC SYSTEM FOR A ZERO EMISSIONS NETWORK ENERGY SYSTEM

Project ID	101101418
PRR 2024	Pillar 4 – H_2 end uses: stationary application
Call topic	HORIZON-JTI-CLEANH2-2022-04-03: Reversible SOC system development, operation and energy system (grid) integration
Project total cost	EUR 5 499 822.50
Clean H_2 JU max. contribution	EUR 5 499 822.50
Project period	1.2.2023–31.1.2026
Coordinator	Fundació Institut de Recerca en Energia de Catalunya, Spain
Beneficiaries	Bosal Emission Control Systems NV; Cluster Viooikonomias Kai Perivallontos Dytikis Makedonias; Diaxiristis Ethnikou Sistimatos Fisikou Aeriou Anonimi Eteria; Ethniko Kentro Erevnas Kai Technologikis Anaptyxis; Eunice Laboratories Monoprosopi Anonymi Etaireia; Fachhochschule Zentralschweiz – Hochschule Luzern; Idryma Technologias Kai Erevnas; Inerco Ingenieria; Tecnologia y Consultoria SA; Kiwa Cermet Italia SpA; Kiwa Creiven SRL; Ostschweizer Fachhochschule; Politecnico di Torino; SolydEra SA; SolydEra SpA

https://24-7zenproject.eu/

PROJECT AND GENERAL OBJECTIVES

24/7 ZEN aims to design and construct a highly efficient 33/100 kW reversible solid oxide cell (rSOC) power-balancing plant, showcasing its compatibility with both electricity and gas grids. The project consortium, comprising diverse expertise, leads innovation in energy management and rSOC system development.

The consortium pioneers advancements across the value chain, enhancing components from cell-level material to fully operational rSOC systems and plug-and-play grid interconnection ecosystems on the demonstration site. Key players include an organisation involved in renewable energy generation (EUNICE), a transmission system operator (DESFA) and an international quality assurance body (Kiwa). The 24/7 ZEN ecosystem will showcase efficient power-to-gas-to-power routes, utilising H_2 or natural gas as fuel, enabling H_2 grid injection, transitioning in less than 30 minutes and achieving a round-trip efficiency of 45 %, all while adhering to standards and safety regulations.

The consortium aims to develop and validate a scalable ecosystem applicable to multi-MW installations. Further research will focus on improving rSOC performance (targeting degradation rates of 0.4 %/kh for 1 000 hours and a current density of 1.5 A/cm^2 in both modes) and enhancing cost-competitiveness (reducing CAPEX from EUR 6 000 / kW to EUR 3 500 / kW).

The project partners that are well connected in the European hydrogen, electricity and grid services sector will disseminate newly developed business models and practices for renewable energy storage, including innovative approaches to delivering green hydrogen.

Through advancing rSOC technology towards commercial deployment, the project contributes to the realisation of renewable hydrogen deployment necessary for achieving a climate-neutral Europe, presenting viable scenarios for grid balancing and green hydrogen supply through conducting in-depth techno-economic analysis.

NON-QUANTITATIVE OBJECTIVES

- Identify requirements for a 24/7 ZEN ecosystem compatible with and connected to the grid.
- Enhance the performance of the 24/7 ZEN system by optimising rSOC cell and stack manufacturing.
- Design, manufacture and test to validate a complete, scalable rSOC system.
- Demonstrate the functioning of the entire 24/7 ZEN grid balance ecosystem for at least 4 months.
- Set out a roadmap exploiting project results for the scaling up and deployment of grid balance rSOC systems.

PROGRESS AND MAIN ACHIEVEMENTS

- Top-level requirements for rSOC system integration with electricity and gas grids have been defined, identifying three integration configurations.
- Significant advancements have been made in enhancing SOC components, particularly in electrode testing and interconnect development. The use of Co-free oxygen electrodes and new composition of Fe-AU doped fuel electrodes has achieved high current densities in both modes of operation
- rSOC stack and hot BoP design and development has led to the creation of detailed designs and simulations of the innovative stack together with the thermal management components on a single body solution.
- Ongoing activities in system integration and design, including conceptual engineering and detailed design, have been conducted to ensure seamless integration of components.
- System requirements and use cases have been clearly defined, addressing critical aspects such as electricity supply, water flow, and natural gas supply.

These results signify a significant step forward in the development of the rSOC system, bringing the project closer to its goal of creating a high-performing solution for sustainable grid management.

FUTURE STEPS AND PLANS

- Advancing scalability of outcomes.
- Scaling enhanced button cells to larger areas and stack levels.
- Integrating components like rSOC stack and heat exchangers into the module.
- Constructing the final system, including pre-designed balance of plant.
- Validating fully integrated rSOC system for grid balancing in Greek energy grid through a 4-month demonstration test.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?	SOA result achieved (by others)	Year in which SOA result was reported
Project's own objectives	Efficiency in SOFC mode	%	57		0.5	2019
	Transient time (SOFC/SOEC)	minutes	30		N/A	N/A
	Electricity consumption at nominal capacity	kW/kg	38.7		40.3	2023
	Round-trip efficiency	%	45		37.90	2019
	Reversible capacity	%	33		0.25	N/A
	Current density of SOFC/SOEC	A/cm^2	1.5	⚙	1.1	2023
	Degradation rate of SOFC/SOEC	%/kh	0.4		1 (SOFC) / 2 (SOEC)	Current density under co-SOEC
	Current density under co-SOEC	A/cm^2	1		N/A	N/A
	Total system power in rSOC	kW	33/100		25/75	N/A
	CAPEX	€/kW	3 500		2 130	N/A
	Efficiency in SOEC mode	%	80		0.81	2021

Clean Hydrogen Partnership
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